Protecting Space Travelers from Kidney Stones

Renal Stone Risk During Space Flight

Renal stones, popularly known as kidney or bladder stones, are small rock-like objects formed in the kidneys or urinary tract by deposits of calcium and other minerals. The problem arises when the stones block the drainage of the kidney, resulting in urinary obstruction and pain. Passing these stones can be one of the most painful experiences a person will endure so doctors often prescribe pain relievers to ease the experience.

Drinking plenty of fluids, which help flush waste out of the body, and eating a well-balanced diet are the first steps to preventing stones. For individuals at risk, this may not be enough, and a doctor may recommend a special diet and medications. Unfortunately, approximately 60 percent of people who have had a renal stone will experience a recurrence. This is particularly true of men, who are four to five times more likely to develop stones than women. Renal stones do not discriminate based on age; even children are at risk.

Astronauts are particularly at risk of developing renal stones because they lose bone and muscle mass; calcium, other minerals, and protein normally used for bone and muscle end up in the bloodstream and then in the kidneys. Without plenty of fluid to wash them away, crystals can form and then grow into stones. This factor compounds the risk for astronauts, since they also perceive that they are less thirsty in space and will drink less than normal during the mission. To minimize all of these factors, doctors must instead treat the stone-forming compounds with medication. This study will use potassium citrate to reduce the risk of stone formation.

Drink plenty of water, Mr. Senator! U.S. Senator and astronaut John Glenn, Jr, takes a break with a beverage tube. Renal stones can usually be prevented by fluid intake, diet, and medication, but researchers are seeking more effective ways to prevent stone formation.

Renal stones are never convenient, but they are a particular concern for astronauts who have limited access to treatment during flight. Researchers are examining how earthbound preventions for renal stone formation work in flight, ensuring missions are not ended prematurely due to this medical condition. During STS–107, earthbound preventions and treatments become astronauts' gain.

Earth Benefits and Applications

- Examine the direct effect of potassium citrate on development of renal stones by determining changes in urine chemicals
- Use potassium citrate to prevent or reduce renal stone formation for patients who have continual problems with renal stones
- Lower the number of hospitalizations per year due to renal stones — 400,000 in the U.S.

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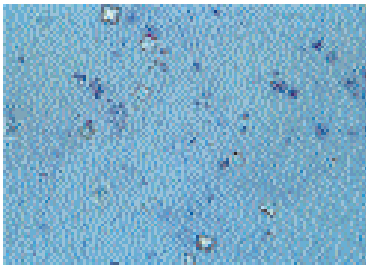
Background Information

Science

Waste proteins, chemicals, and minerals move from the bloodstream and are filtered out by the kidneys. Usually, if a person drinks enough water, this diluted waste is washed out as urine. However, painful renal stones occasionally form.

Changes in diet (in the United States, vegetarians are half as likely as meat-eaters to develop stones) and an increase in fluids can minimize stones, but for some, these precautions are not enough. A number of medical conditions, such as osteoporosis and hypercalcuria, also increase calcium and other minerals in urine and cannot be corrected with diet alone.



The micrograph shows calcium oxalate crystals in urine. These small crystals can develop to form renal stones.

Potassium citrate, used in the STS–107 study, is a common preventive treatment for renal stones. Citrate binds to calcium in the urine, preventing the calcium from crystallizing and developing into a stone. Citrate also makes the urine less acidic, reducing the risk of uric acid stones. By testing potassium citrate on astronauts, who have no medical conditions other than exposure to space to be at risk for stones, researchers examine the direct effect of the medication on excess minerals and the potential development of stones.

Operations

During STS–107, each crewmember receives a packet of pills. They take two pills at dinnertime, beginning three days before launch and ending 14 days after landing. The crewmembers also log everything they eat or drink, when they exercise, and what medication they take. They provide samples using urine collection kits.

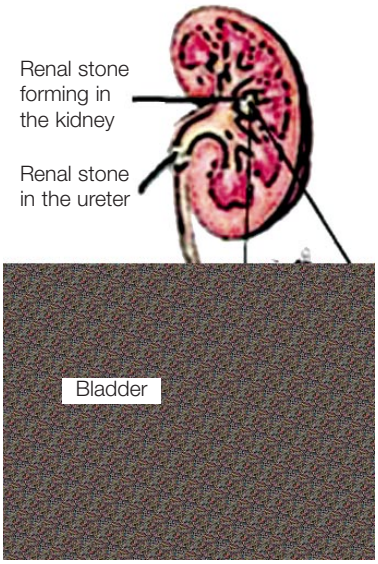
After flight, researchers measure how much urine each crewmember voided during the mission and examine it for stone-forming chemicals, such as calcium and sodium. They also check the urine's pH, to see if the potassium citrate raised the pH to a less acidic value. The STS–107 data will be compared with results obtained from *International Space Station* (*ISS*) missions. Participation by the *ISS* Expedition Three crewmembers, who were in space for several months, helps researchers determine the effectiveness of potassium citrate over a longer period of time.

Hardware

Each urine collection kit comes with a urine collection device (UCD) designed for either men or women. Each UCD contains lithium chloride, which acts as a volume marker when it is filled. By measuring the amount of lithium in the urine sample, researchers determine how much urine the astronaut produced during flight. The astronaut uses a syringe to remove a small sample from the UCD. Both the UCD and the syringe sample are closed in a leak-proof container and stored at room temperature until the end of the flight, when they are returned to a laboratory for careful analysis.

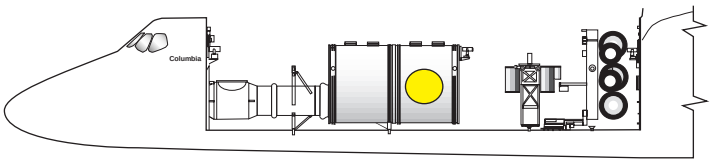
Earlier Results

While in space, astronauts have an increased risk of developing stones due to 1) the excess salts and minerals in their bodies, 2) the fact that they drink less fluids, and 3) the lower volume of urine produced. Earlier studies show that drinking extra fluid after flight, during the period when astronauts are readjusting to normal gravity, helps reduce the risk of renal stones. Drinking extra fluid in flight, however, simply washes the excess salts and minerals into the kidneys, increasing the astronauts' risk of developing stones. This makes medication, such as potassium citrate, the most promising way to stop stone formation.



Stones can form in the kidney, ureter, and bladder. New treatments involving medication, ultrasound, or other non-invasive methods allow doctors to break up larger stones that cannot pass through the ureter.

On the ground, potassium citrate, combined with a carefully regulated diet, has shown promising results in reducing the risk of stone formation. For those with stones, taking potassium citrate can significantly reduce the recurrence of a renal stone.



Approximate location of this payload aboard STS–107.